DECISION SUPPORT – MORE THAN JUST TECHNOLOGY

Plough operation module on board a water-injected dredger vessel

Decision support systems are a growing development in the maritime industry. Current technology allows the processing of various data sources with complex algorithms resulting in support for the crew on board. Often complex technical solutions are found with the objective to improve safety or increase efficiency of operations. This sounds promising, but why is the introduction of such high-tech solutions not always as successful as expected beforehand?

The approach in development is often taken from a technical perspective. The most state of the art, complex techniques are available for use on board and engineers are eager to develop them. But sometimes the basic principle is lost: technology should support the operator and the human's role is not to satisfy the technology. In this article, we want to show the risk of underexposed human factors and the options available to incorporate them properly.

Seeking balance

Various operations are becoming more complex or are intended to be performed by a smaller crew, which increases the task complexity for individual operators. Technology progresses rapidly and data processing power allows the provision of a lot of information for the crew. The essence is to provide the crew with sufficient information, not overloading them with details, in time and unambiguous. In reality, this proves to be a challenge. If successful, it supports the crew and allows cooperation, even when the crew members have various backgrounds and experience levels.

Complex technology

Development is often approached from a technological perspective. Explainable, because in many cases complex technology is required. Furthermore, the decision support must be of a high level, otherwise trust in automation is too low.

An engineering perspective on a tool is different than the user perspective. The user has a preference for a clear spot-on tool providing the essential information for the task at hand. It should be clear at one glance which action is needed.

For the operator, the decision support system will likely be one of many systems operated to perform his overall task. The engineer on the other hand might be tempted to keep all options open and provide background information, which is not directly essential to the operator's task. While engineering a single decision support system, the focus is often on the one system and not on the operator's full task. This difference in perspective leads to different requirements and therefore different design choices.

Finding the right balance between simple and sufficient is a challenge. The art of leaving things out is difficult, but important. Of course, it is tricky to omit things that might be relevant. Therefore, it is very important to understand the operation and the information used by the operator to make a decision. On the other hand, the way of working and the information used at this moment should not limit developments.

Understand the context

A good understanding of the daily operation on board is essential as a starting point for the development of decision support tooling. Understanding the task distribution between crew members, the type of decisions to be taken, time pressure under which decisions need to be taken, other tasks that need te be performed in parallel with the task at hand, etc. All these factors will impact the decision support tool requirements and its use.

> One main design guideline to be applied is "less is more"

The user interface should match the task and responsibility of the user, for example: do not mix advice for captain, DP operator and surveyor in one tool.

Be very aware who the end user will be and what his/her tasks and responsibilities are.

To get to the best result, it is important to involve the future user in the design and development. This is very obvious for many tool developers, but not always common in the maritime sector. The distance between "office" and "on board" is often larger than desirable. This is not surprising, because the future users are often at sea and the distance, therefore, literally is large.

Define requirements together

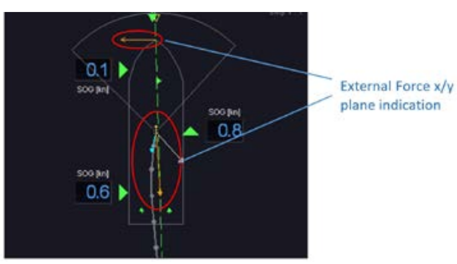
Once a good understanding of the operation is available, the system functionality can be defined. This includes not only the functionality in the sense of data sources, algorithms and alerting boundaries, but it also includes a user interface that provides the required information to the operator. One main design guideline to be applied is "less is more".
Decision support systems often include various data sources with data collected over a certain time span. Data required to provide the crew with good support, but not necessarily data to be presented to the operator. Including users in defining the user interface is key to determine the right level of detail of information to be presented.

Iterative design process

Once the requirements for the system and its user interface are defined, many design decisions still need to be taken. During this design process, it is essential to include operators to evaluate prototype versions of the system, allowing them to reflect on the design from an operational point of view. With a structured cognitive walkthrough, design decisions may be added or altered. Allowing multiple iteration steps in the design will allow for a first-time right installation.

Rules of the game

How brilliantly the decision support system might provide support to the crew, the crew still needs to know how to act on it. If a support system provides advice, is the crew required to adhere to it? Is the crew required to call the office? If the advice is not followed, who is accountable for the consequences in terms of reduced efficiency, workability, safety?
The issue can be illustrated by the situation in which a decision support system uses traffic light colours. What does orange mean? Abort operation? Continue operation applying additional safety procedures? The frontline operator will perform his/her task under time pressure and will not be capable of evaluating the situation to determine how to interpret the "orange" advice. It requires clearly defined rules established between frontline operators, being the crew on board and the company management ashore.



Main screen, forces/momentum indication, the arrow indicates the direction and the length is chosen such that the impact of the forces is visualised.

Automatic intervention of the system, the operator is "on" the loop and informed on the situation, no further action is required as the system automatically acts upon the situation. If the speed reduction is too fast/slow, the operator can intervene, the orange blinking colour is used to catch the operator's attention.

PLOUGH OPERATION MODULE BY RH MARINE

An example of a decision support system is the successful implementation by RH Marine of a plough operation module on board a water injection dredger. The vessel is intended for dredging at a pre-defined location. For these locations, a dedicated survey system is used. Various tasks require good cooperation and communication. Integrating this cooperation within the systems, will reduce the crew's workload.

Smart integration of systems

The first step is that the operator who monitors the results of the main operation (surveyor) can directly implement small changes in track and speed to optimise the result of the ploughing operation. With this, the vessel operator is relieved of continuously changing the track/speed setpoints. One step further is the smart integration of the plough forces and the dynamic positioning and tracking system (DPT). With this integration, the DPT system indirectly monitors the status of the plough operation.

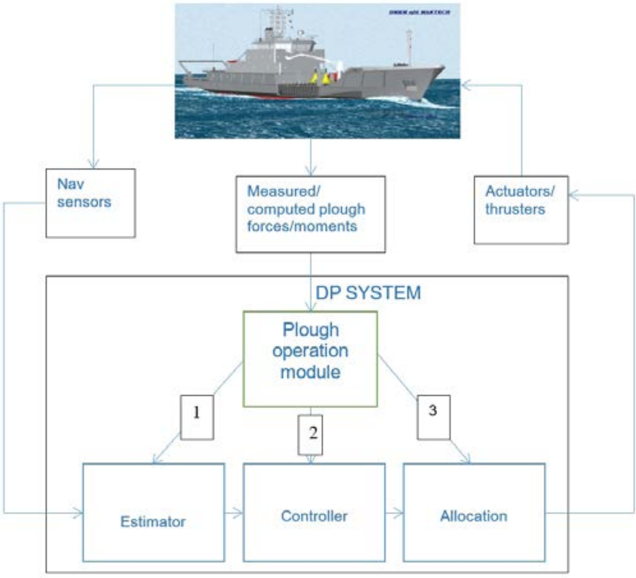
Philosophy of implementation

Implementation of the plough operational module is based upon a two-step philosophy:

1. Smart algorithm performing complex analysis in order to produce operational advice.
2. An intuitive way of presenting this advice or automated actions, such that they can be easily interpreted on an operational level.

Automation of tasks

In some cases, for example if the forces exerted on the plough are too large, or the plough is stuck and has to be retrieved, it is required to slow down. It would then be desired to keep station with the vessel. By feeding the DPT system with this information, it will automatically slow down or keep station to support the main operation. With this integration, an extra task is automated, enabling the vessel operator to focus on overseeing the complete operation including navigation.



The system will detect the plough status based on forces and frequencies of forces on the plough.

Technical implementation

From a technical perspective, the algorithm is complex. The forces and moments are read in the plough system and are fed through in the DP control system. Within the DP control system, these forces are used in several functional blocks.
The starting point of implementation was defining the different operational situations together with the end customer, where the operator normally should act and where in this case the system will act in order to relieve the operator from extra monitoring and interpreting and even taking action. Moreover, human operator error due to multi-tasking, higher workload and overload of data or information is also addressed.

Based upon the identified operational situation, the system will act differently. The schematic figure of the system elements explains that the system will detect the plough status based on forces and frequencies of forces on the plough. Depending on the outcome, various actions can be initiated automatically or advised. For example, changing the DP gain setting, adapting the speed over ground (SOG), transfer from sailing to station keeping, etc.

Human Machine Interface implementation

The technical detail level of the plough module is filtered to an operational level in the Human Machine Interface (HMI), in such a way that the operator can easily recognise the operational situation and can act upon it. In the HMI, only minimal elements can be found: an arrow indicating the forces, a digital speed setpoint indicator with multiple states and an indication on action to be taken by the operator or informing the operator about the automated action taken by the system. Though the algorithms are complex and represent high-end technological solutions, the user is informed by relatively minimal HMI elements to support the operator in the task at hand without distracting. The rules of the game are basically included in the HMI by means of the alarm line, which indicates the action taken by the system or action expected from the operator.
The result is an increased level of automation or support to the operator allowing the operator to focus on other tasks and reducing human error.

Water injection dredger.

Implementation of the system on the bridge of the water injection dredger.

Both crew and management will have their own expectations of the investment made by installing the decision support system on board. The rules of the game materialise the expected benefits in the day-to-day operation.

Generally spoken, various levels of support can be defined:

- I inform you about a situation.
- I suggest you take one of the following actions to avoid a situation.
- I demand to take the following action to avoid a situation.
- I took corrective action for you; all is well now.

Helpdesk after implementation

In many cases, decision support systems require various data sources, system settings and pre-defined parameters for a specific type of operation. Feeding the system with the right data sources is essential. Who will perform this task? The crew as well? It is worthwhile zooming in on this question and a more logical approach might be to have "the office" taking care of this task as an operational helpdesk. It requires different skills than the nautical ones the crew is trained in.

Allowing multiple iteration steps in the design will allow for a first-time right installation

Apart from operational support, technical support might also be required. Complex systems, with various data sources and having many settings, might stall and present an error message. A technical helpdesk functionality might be required, depending on the role of the decision support system. Whether it is a support system required to be up and running 24/7 or it concerns a nice to have add on defines different requirements on the technical support. Defining this beforehand is essential for a successful implementation and crew acceptance of it.

Pitfalls

Development of high-tech decision support systems has the risk of running into technical problems and delays. A pitfall often seen in these kinds of projects is that the focus remains on the technological development of the system. Any delay in the process is absorbed by later phases of the implementation path. Cutting corners in creating a user interface without operator involvement saves time, but results in a less optimal user interface. Not defining the rules of the game having both the onboard crew and office crew involved saves time, but creates risk in low crew acceptance, ill use or neglect of the system and not meeting the expectations of the investment. Skipping training saves time as well, but meeting the objectives of the decision support system with a non-trained crew is hard.

Technology should support the operator

The message we aim to stress is best summarised by the following statement: Technology should support the operator, the human is not there to satisfy the technology.

For a successful implementation, various methods and tools are required, which seem expensive at a first glance, but will prove to be money savers in the long run. MARIN is currently supporting this process of introducing new technology for a number of customers.

Hans Huisman
Team leader Human Factors at MARIN, h.huisman@marin.nl

Willemijn Pauw
Senior project Manager at MARIN, w.pauw@marin.nl

Ehab el Amam
Consultant at RH Marine, ehab.elamam@rhmarine.com